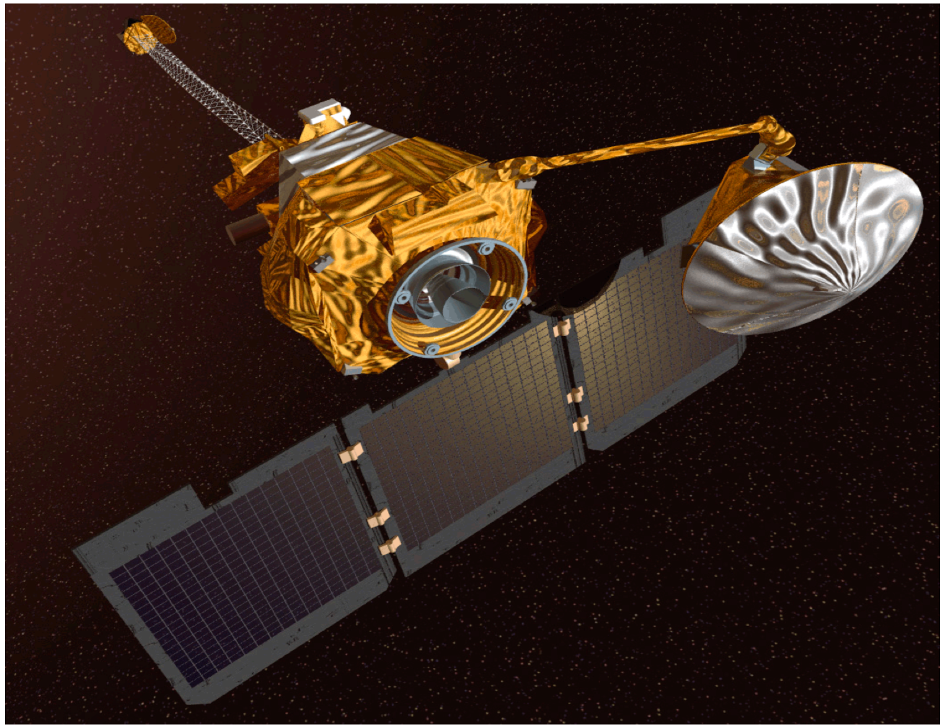
2001 Mars Odyssey

Jet Propulsion Laboratory
California Institute of Technology



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This document has been reviewed for export control and it does NOT contain controlled technical data.

Spacecraft Status (1/3)

- Mars Odyssey celebrated the 20th anniversary of arrival at Mars (October 2021)
- Currently in Extended Mission 8; proposal submitted for “E9”
- The Odyssey spacecraft and its subsystems are nominal and continue to operate at high efficiency
- The Thermal Emission Imaging System (THEMIS) and two neutron detectors, the High Energy Neutron Detector (HEND) and Neutron Spectrometer (NS) instruments are functional and healthy
- Odyssey continues to provide high-value relay services to InSight, Curiosity, and Perseverance operating on the surface of Mars

Spacecraft Status (2/3)

- The Odyssey spacecraft continues to operate nominally using Y- and Z- axis reaction wheels along with the skew wheel
  - The three operating wheels show no sign of degradation
- All Stellar Attitude Determination mode preserves IMU life
- Some spacecraft components are close or past their projected lifetime
  - No indications of degradation are observed
- Hydrazine propellant is a prime limiting commodity potentially impacting the life of the mission
  - A recent Propellant Gauging System Study led to a downward revision of the estimate of remaining fuel
  - However, sufficient fuel remains to conduct the new proposed extended mission

Spacecraft Status (3/3)

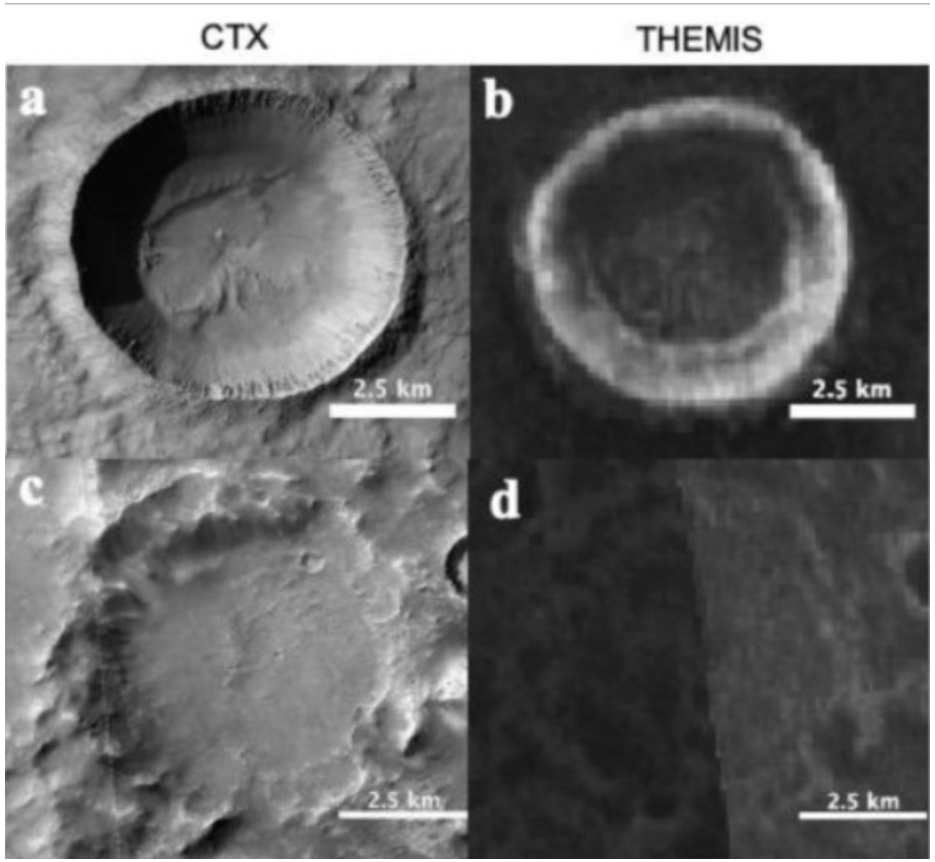
- Spacecraft Battery is aging but fully functional
- The High Gain Antenna gimbals continue to operate nominally with no indication of degradation
- The UHF relay system is fully functional and ready to support the extended mission
- The Mars Odyssey team continues to carefully manage consumables

Science Highlight – Crater Degradation from THEMIS Thermophysics

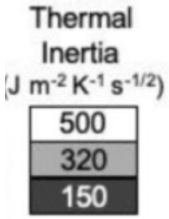
The relationship between thermal inertia and degradation state of craters in areas of low surface dust cover on Mars.

Beddingfield, C. B., Moersch, J. E., & McSween Jr, H. Y. (2021). *Icarus*, 114678.

- The authors examined numerous craters in three widely separated study areas.
- They noticed that nearby craters could have substantially different thermal inertia signatures.
- These differences correlated with rim irregularity, another measure of crater degradation.
- As craters erode, their rims become covered with a layer of comminuted rock. In areas with low dust cover, this layer obscures the normally bright thermal inertia signature associated with fresh craters.
- As a result, thermal inertia can be used as a proxy for degradation state.



A comparison between the CTX morphology (left) and thermal inertia (right) of a fresh crater (top) and a degraded crater (bottom), showing the correlation between thermal inertia.

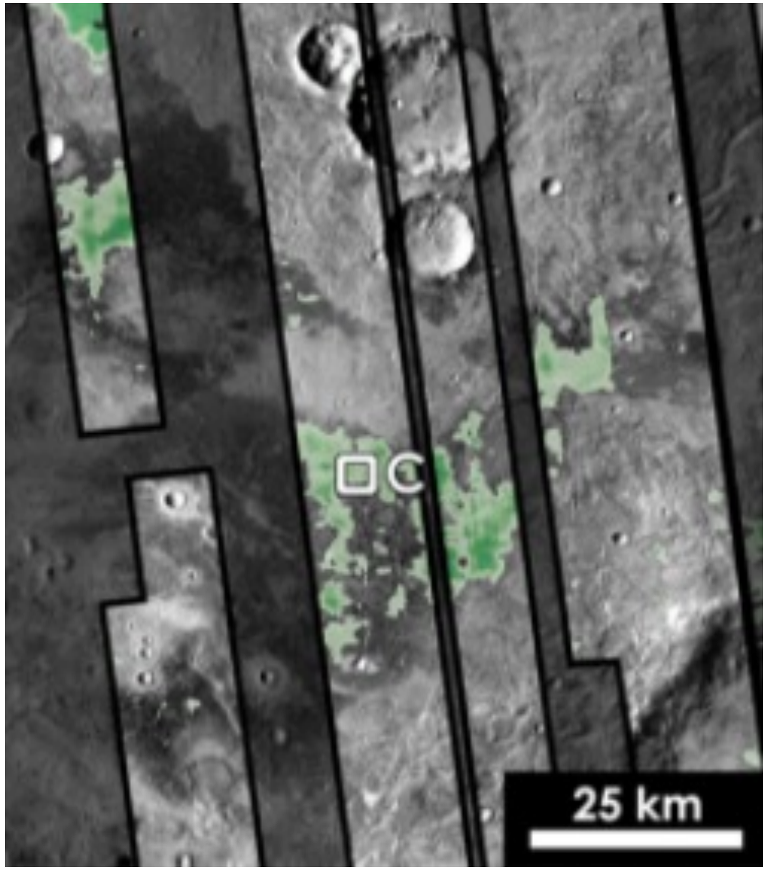


Science Highlight – Olivine in Bedrock or Regolith from THEMIS Spectral Images

Investigating Sources of Spectral Olivine Enrichments in Martian Bedrock Plains Using Diurnal Emissivity Changes in THEMIS Multispectral Images

Cowart, J.C., Rogers, A.D. (2021).
Journal of Geophysical Research: Planets, 126, Iss 11, e2021JE006947.

- Olivine-rich bedrock outcrops in the Noachian Highlands provide evidence for voluminous ancient volcanism with little subsequent alteration by water.
- However, the olivine signature could simply be due to concentration in olivine in surface cover (sands).
- The authors observed the regions of interest using THEMIS images taken just after dusk, to catch the period when sand cools down and rocks briefly dominate the spectrum.
- They find that the olivine signature is greater in the rocks vs the sand, indicating that the high olivine is indeed a characteristic of the bedrock.



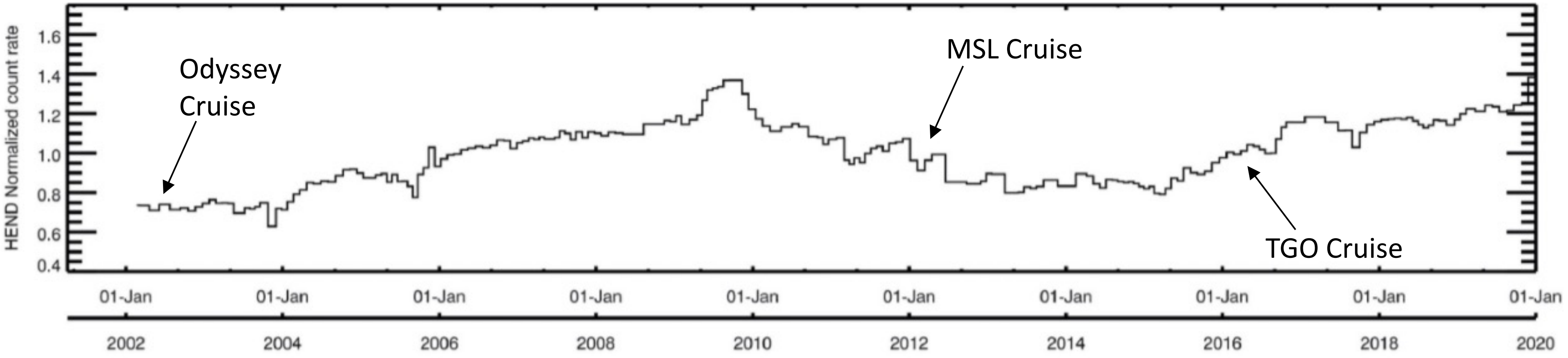
THEMIS daytime temperature map of bedrock plain with CRISM olivine multispectral parameter product overlaid

Science Highlight – 20 Years of Radiation Monitoring by HEND

Observations of neutron radiation environment during Odyssey cruise to Mars

Litvak, M.L., Mitrofanov, I.G., Sanin, A.B., Bakhtin, B., Golovin, D.V., & Zeitlin, C. (2021). Life Sciences in Space Res., 29, 53-62.

- Three spacecraft with neutron-measuring instruments have flown to Mars in the past 20 years, making rare measurements of the interplanetary radiation environment.
- By comparing Odyssey's 20-year neutron measurement baseline in Martian orbit to those of other in-transit spacecraft (MRO's DAN and TGO's FREND), Litvak et al. were able to extrapolate Odyssey's measurements across two solar cycles, estimating the total radiation dose that could be encountered by astronauts given transits at different points in the cycle.
- The minimum total dose takes place at solar maximum, because while the solar wind itself includes harmful radiation (especially during large particle events), it protects the Solar System from more energetic Galactic Cosmic Rays.



Measurement of the neutron flux from Odyssey's HEND instrument during the transits of Odyssey, MSL, and TGO.

Science Objectives for the Extended Mission

The science objectives proposed for Odyssey's E9 mission address both the breadth and depth of the consensus goals for Mars exploration from the Decadal Survey and the Mars community (MEPAG)

E9 Science Investigations (1/2)

MEPAG Goal I (Life)

- Search for thermal anomalies associated with active subsurface hydrothermal systems having the potential to host liquid water and/or brines
- Investigate and map the surface geological context of sites favorable for past life, including the surface response to diurnal and annual thermal cycles, and identify landing sites likely to represent hydrothermal or subaqueous environments

MEPAG Goal II (Climate)

- Determine the spatial and temporal distribution of atmospheric temperature, pressure, water vapor, and dust
- Study processes of cloud dynamics and surface frost at morning daylight local times
- Characterize energy inputs/outputs at the surface (e.g., reflected light, emitted radiation) that are contributors to surface energy balance (an atmospheric forcing mechanism)
- Map the distribution of ice and dust layers in the Polar Layered deposits (PLD), and the extent of glacial and peri-glacial features
- Determine the thickness of seasonal CO_2 frost
- Map the hydrogen abundance and infer the depth of water

E9 Science Investigations (2/2)

MEPAG Goal III (Geology)

- Investigate the processes operating in the north and south polar caps at all seasons
- Study sedimentary, igneous, and impact geology and processes (surface roughness, crater degradation, grainsize of deltas and alluvial fans), as well as landing site characteristics, including rock-size distribution

MEPAG Goal IV (Humans)

- Monitor the radiation dosage at Mars
- Characterize solar particle events at Mars
- Landing site safety, including rock-size distribution

Data Archiving and Professional Development

Data Archiving

- Odyssey science teams will extend their near-perfect record in delivering validated raw and higher level data products to the Planetary Data System (PDS) on a quarterly basis

- The instrument teams will update their data delivery pipelines to the new PDS4 standards, within the guideline budget

Professional Development

- The Odyssey Project is committed to diversity, equity and inclusion and to providing opportunities for early career scientists and engineers

- Five funded Co-Investigators mentor graduate students, who regularly attend science team meetings, publish peer-reviewed research papers with Odyssey data, and participate in science observation planning

- The Project encourages and develops a cross-discipline engineering workforce that expands learning and growth opportunities within the team

Extended Mission Budget

- Odyssey can meet the major scientific objectives for the E9 mission within the allocated budget (“Guideline”) of $11.0M per year

- The budget covers fiscal years 2023–2025 (September 26, 2022 to September 28, 2025)

- The proposed three year E9 extended mission is challenging but achievable within the NASA approved guideline NOA

- The main challenges for the budget process are the flat funding profile, the difficulty of operating an aging spacecraft, and the impact of inflation